

Amendments to the Specification

A1 [0004] Magnetic materials with highly uniaxial or perpendicular anisotropy such as Cobalt-Chromium (CoCr) based alloys, Cobalt-Palladium (Co/Pd) and Cobalt-Platinum (Co/Pt) type multilayers, Barium-ferrites (Ba-ferrites) and $L1_0$ - ordered phases have been proposed as the perpendicular recording layer either with or without a soft magnetic keeper layer, or soft magnetic underlayer (SUL), underneath the recording layer. One role of the SUL is to focus the magnetic flux from the write head into the recording layer. This enables higher writing resolution in the double layered perpendicular media with SUL, compared to that in single layer perpendicular media without a soft magnetic underlayer. SUL material must be magnetically soft with very low coercivity (less than a few Oersteds), and have high permeability. The saturation magnetization of the SUL needs to be large enough so that the flux saturation from the write head can be entirely absorbed without saturating the SUL. Based on these requirements, a ~~numbers~~ number of soft magnetic materials may be suitable as SUL, e.g. as permalloy, Cobalt-Zirconium-Niobium (CoZrNb), and Iron-Aluminum-Nitrogen (FeAlN).

A2 [0006] Several alternatives have been proposed to achieve this single domain state: (1) Applying an external field inside the disk drive, e.g. generated by hard magnets. This approach would require architectural changes to the disk drive to solve the SUL noise problem rather than solving the noise problem within the media themselves. (2) Exchange coupling of the SUL to a hard magnetic layer, which is magnetically oriented, i.e. in a single domain state. In this proposed scheme a CoSm or a similar hard magnetic pinning layer must first be generated ~~first~~. The easy magnetic axis can be oriented in the disk radial (cross track direction) and the subsequently deposited soft magnetic material (e.g. CoZrNb) aligns with the pinning layer due to direct ferromagnetic exchange interactions. (3) Exchange coupling of the SUL to an ~~Antiferromagnet~~ antiferromagnet. This approach relies on antiferromagnetic interactions rather than ferromagnetic

A² interactions to pin the SUL in the radial direction. The antiferromagnet, e.g. IrMn is again oriented in the radial direction by applying a field during film growth, e.g. sputtering.

A³ [0009] It has been discovered by the inventors that the iron-cobalt (FeCo) based high saturation magnetization materials can be fabricated with the magnetic easy axis aligned in the radial direction in the disc substrate without the processing and/or structural complexities described above. Addition of ~~glass-forming~~ glass-forming materials such as boron (B), and carbon (C) maintains the SUL layer in amorphous or nano-crystalline state to provide extremely smooth surface and high magnetization, which are also the basic requirements for making ~~had~~ hard disc drive medium.

A⁴ [0024] The substrate 22 can be any conventional substrate well known in the art such as a glass material or an aluminum or aluminum magnesium alloy. For example, the substrate 22 may be ~~an~~ a glass-ceramics composite substrate of between 31.5 and 50 mil thickness. Preferably, prior to depositing the soft magnetic underlayer 19, an adhesion layer 37 is provided on the substrate 22. This adhesion layer 37 may comprise a tantalum (Ta) layer having a thickness of about 1-5 nm. After this adhesion layer 37 has been deposited, the soft magnetic underlayer 19 is deposited thereon.

A⁵ [0026] In order to manufacture the magnetic recording medium of the present invention the steps shown in the flow chart 40 of Figure 4 are preferably followed. As shown in Figure 4, the disc substrate 22 is provided 43. In order to prepare the disc substrate 22 for deposition of the layers, it is preferably preheated for cleaning 46 at a power level of about .005 kW for a period of about seven seconds. The tantalum adhesion layer 33 37 is then deposited 49 thereon to the thickness of between 1-5 nm, and most preferably at about 5nm. The soft magnetic underlayer 19 is then deposited 52 thereon, such as by the sputtering technique, and has a total thickness between 150-300 nm, and most preferably of about 200-240nm. A second tantalum layer of about 3 nm is

provided thereon 55 so as to provide the protective interlayer 28 for the deposition of the actual perpendicular recording material 25 on the soft magnetic underlayer 19. A flash annealing process may be performed 58 prior to the deposition of the alloy recording media 25 to maximize the magnetic properties of this soft magnetic underlayer 19, which annealing process preferably is done at a temperature of 100-200°C for a period of about seven seconds. This provides a power output of about 2.5 kW to the structure. At this point the recording alloy is deposited thereon 61 to provide the finished magnetic recording medium.

[0027] The inventors have also discovered a perpendicular magnetic recording material, provided by an exchange decoupled cobalt/noble metal perpendicular media by grading the cobalt alloy thickness, and which is disclosed in co-pending application Serial No. 10/032,721, filed on December 27, 2001 and assigned to the present assignee. The specification of the applicants' co-pending application is hereby incorporated by reference in its entirety herein.

[0028] As shown in Figure 2B, the soft magnetic underlayer 19 is preferably provided as laminated structure 34. Preferably this laminated magnetic underlayer structure 3 is comprised of alternating layers of an 34a, 34b, 34c, of an iron-cobalt-boron alloy (Fe Co B) and tantalum layers 64a, 64b, 64c. Preferably the individual iron-cobalt-boron layers 34a, 34b, 34c are about 80nm or less in thickness and the tantalum layers 64a, 64b, 64c are between 0-5 nm in thickness. That is, at for a tantalum layer of 0 nm in thickness, the iron-cobalt-boron layer is generally continuous. In the most preferred embodiment, such alternating layers are deposited on the substrate to provide the laminated soft magnetic underlayer 34 for the perpendicular recording medium 10 herein. Alternatively, there may be a first iron-cobalt-boron layer of about 80 nm in

A7 thickness and a second such layer of about 160 nm in thickness, separated by a tantalum layer, so that the total SUL layer is about 240 nm thick.

A8 [0029] In the most preferred embodiment, the ~~iron-cobalt-boron~~ iron-cobalt-boron alloy comprises about 90% FeCo alloy and about 10% ~~Boron~~ boron. Most preferably, the FeCo alloy comprises about 65% of Fe and 35% of Co.